The Proceedings of the International Conference on Creationism

Volume 7 Article 39

2013

Stability and Change in Students' Views of the Origin of the Universe: A Selected Review of the Literature

Sarah M. Walsh

Proceedings of the Seventh International Conference on Creationism.
Pittsburgh, PA: Creation Science Fellowship

STABILITY AND CHANGE IN STUDENTS' VIEWS OF THE ORIGIN OF THE UNIVERSE: A SELECTED REVIEW OF THE LITERATURE

Sarah M. Walsh, M.S.

KEYWORDS: Young Earth Creation, Evolution, Science Education, Acceptance and Rejection

ABSTRACT

The creation/evolution education debate has been raging for the last century in schools, school board meetings, and communities creating a divide between those who believe in the Judeo-Christian creation account and those who believe in naturalistic evolutionary theory. This paper seeks to decipher the effect of this controversy on high school and college students, particularly in the public educational realm by a literature review. Evolutionary educational researchers are found to advocate a one-sided view in the teaching of origins to the point of indoctrination through their techniques, resources, measurement instruments, etc. Parents of public school students, and the students themselves, who reject evolutionary theory would benefit from this study as it enables them to prepare for possible situations arising in the science classroom.

INTRODUCTION

Purpose of the Study

The purpose of this study was to review current literature on the teaching of origins, in search of answers to the following questions:

1. What measurements are used to determine students' views of origins, prior to instruction?

2. What techniques are used to teach students about the origins of the universe?

3. What resources are used to teach students about the origins of the universe?

4. What evidence exists regarding stability/change in students' views of the origin of the universe?

5. What factors are identified that contribute to stability? What factors are identified that contribute to direction and magnitude of change?

Importance of the Study

Current teaching on the origin of the universe in the public schools does not appear to be based on generally accepted approaches of an even-handed generation of evidence and the use of that evidence in building a model that is internally consistent. Thus, this study is important because it

reveals the ways in which a worldview is being inculcated at the expense of sound teaching on the generation of evidence and the building of internally consistent models.

The disruptive influence on family values has only recently emerged as a negative consequence of the current approach to teaching the origin of the universe. Therefore, this study is important because it sheds light on the changes that occur in students' beliefs when they are exposed to 'one-sided' learning experiences that are being heralded as exercises designed to accomplish an otherwise acceptable outcome.

FINDINGS AND DISCUSSION

Research Question 1: What measurements are used to determine students' views of origins, prior to instruction?

The reliability of the measurement instrument called Measure of Acceptance of the Theory of Evolution (MATE) with University students is discussed by Rutledge and Sadler (2007). This tool is composed of a 20-item Likert-scale instrument designed to assess high school biology teachers overall acceptance of evolution. The instrument is composed of multiple items addressing evolutionary concepts to measure the effect of instructional strategies that emphasize the nature of science as a method of inquiry and critical thinking. Statements presented in the instrument are quite effective in finding out what a student's beliefs are regarding origins. Students are asked to rate how much they agree or disagree with each of the statements given. For example, statement number fourteen evaluates the agreement or disagreement of the validity of evolutionary theory in regard to the Biblical account of creation. Another statement asks the students if they agree with a young age of the Earth on the scale of thousands of years rather then billions.

Matthews (2001), in her article on the effect of a curriculum containing creation stories uses a survey to find students' attitudes toward evolution before instruction is administered. The author states that the curriculum needs to address students' preexisting notions about the origin of life in order for conceptual change to occur, and this survey provides for this goal. The sample was students from a general biology course at a junior college in New York. The questionnaire assessed the belief in special creation or evolution and related beliefs. One question (#14) in particular probed the students' sense of the importance of evolution to an understanding of the discipline of biology and their notions about scientific literacy. Nonscientific notions would include vitalism and special creation.

A scoring rubric was designed by Hatch, Hsu, Jenson & Moore (2007) to help teachers evaluate students' understandings of biological evolution. The authors note that many publications discussing what is to be taught with evolution exist, but then provide little help with assessment and evaluation. The framework of the rubric is divided into four Darwinian components, including variation, genetics, differential survival and reproduction and change over time. Student responses to questions are classified within the rubric and there may, or may not, be evidence that a student's response contains ideas or concepts from a specific Darwinian category. An example is one question given to freshmen high school biology students:

> Cheetahs (large African cats) are able to run faster then 60 miles per hour when chasing prey. How would a biologist explain how the ability to run fast evolved in cheetahs, assuming their ancestors could only run 20 miles per hour (Hsu, Jenson & Moore, 2007, p. 395)?

The example given here assumes that evolution occurred and may in turn pressure students to conform to evolutionary ideas for fear of being scrutinized by their teacher. Due to the subjectivity of this scoring rubric, the author stresses that consistency is key for accurate scoring. It is concluded that information used by students is current scientific thinking, but much of it is inconsistent, and many students' responses are not so much wrong but out-of-step with recent scientific findings. Furthermore, the key is to teach students to use this rubric to solve novel evolution problems rather then simply recite the key phrases of the four components.

Many studies have shown that students harbor misconceptions about key microevolution ideas, but very few studies focus on misconceptions on macroevolution. In an article by Herron *et al*. (2007), a measurement instrument is used to gauge students' misconceptions on macroevolution, or more specifically, evolutionary trees. The instrument was developed from a questionnaire that consisted of questions designed to elicit anticipated misconceptions thought to be common among college students. To fully elicit students' thought processes and provide as little prompting as possible, questions remained open-ended. Students were required to draw diagrams, write short essays, or provide written explanations of their answers. Four major misconceptions were found about evolutionary trees: incorrect mapping of time, tip proximity indicates relationship, node counting, and a straight line equals no change. The authors then discuss skills students need to learn in order to correctly interpret evolutionary trees. The author states that the misconceptions uncovered by this instrument are barriers to understanding how evolution operates, and that phylogenetic reasoning is central to much contemporary research on evolution.

Moore and Cotner (2009) in their article on the association of teachers teaching creationism in high school biology and college students' views on evolution conducted a survey on college students enrolled in an introductory biology course. The student sample included biology majors and non-majors. The survey began with a question asking the students to explain whether their high-school biology course included the following: evolution but not creationism, creationism but not evolution, both evolution and creationism, or neither evolution nor creationism. The students were then asked to respond to the twenty statements in the MATE instrument, which was described above. The authors conclude that the survey revealed that creationism continues to be a part of about one fourth of high-school biology classes. Furthermore they also state that this violates the recommendations of numerous professional scientific organizations and states' science-education guidelines. The practice of teaching creationism has been deemed unconstitutional.

Blackwell, Dukes and Powell (2003) suggest the use of a simple 'test' formulated not to try to impose knowledge and belief in evolution on the student, but to attempt to direct students toward the application of information on evolution to material already familiar to them. It is hoped that this process would cause students to naturally incorporate at least some of the ideas of evolution into their own belief systems. As an introduction to evolution for students in introductory biology (college or secondary school), a brief evolution 'test' is proposed. The purpose of the

questionnaire is to initiate a personally meaningful consideration of evolution, and to further strengthen a student's existing belief system concerning biological science.

The 'test' can be a series of objective questions about particular life experiences posed to pique the interest of the students without threatening their beliefs. The questions should also not have correct answers but should ask what the students think or believe about a given statement. This is consistent with the constructivist theory of teaching and learning which emphasizes the significance of the individual learner's previous knowledge. The questionnaire is based on the evolution of dogs and dog breeds since many students have an experience with or fondness for dogs.

Amirshokoohi, Donnelly, and Kazempour (2008) explored high school students' views about evolution and evolution instruction and how student acceptance is related to those views. Their study was guided by the following four research questions:

1. What are high school students' acceptance/rejection positions on evolution?
2. How do high school students perceive their evolution learning experiences?
3. What are high school students' views on whether evolution should be taught?
4. How do evolution acceptors and rejecters differ with respect to their views of evolution learning and teaching?

The participants of the study were thirty-three U.S. high school biology students all who had the same biology teacher. Data collection and analysis consisted of qualitative and quantitative methods and included individual interviews, open-ended written responses to various prompts, and Likert scale items.

This study found that evolution acceptance surfaced often when students were describing evolution learning experiences and ideas about evolution teaching. When students described their views of teaching evolution they desired a balanced approach that included alternative explanations. The authors noted that students would not be so inclined to call for a balanced approach if they knew the legal and practical implication of this choice. It is then suggested by the authors that perhaps biology should do more to discuss the difference between science and religion and how science relies on naturalistic methodology and explanations as recommended by the NSTA (National Science Teachers Association).

Students' reasons for including evolution are suggested to justify the instructional approach of biology teachers. When the authors point out that many students noted that evolution opposed their religious views, it is suggested that students would benefit from learning about different religious denominations' stances on evolution. It is further explained that many Christian clergy members hold compatible views of evolution and religion and that local clergy could serve as allies for evolution instruction.

Research Question 2: What techniques are used to teach students about the origins of the universe?

Cook (2009) suggests a project-based evolution unit for high school students to help improve their understanding of evolution. This project based learning (PBL) includes hands-on and technology based inquiry activities guiding students through a modern-day application of evolutionary theory. Cook's motive for introducing this type of lesson plan is to overcome obstacles of teaching evolution. She points out several barriers science teachers face such as "intuitive ideas held by students, teleological thinking, and the influence of strongly held personal beliefs" (Cook, 2009, p. 95). She explains that misunderstandings can be highly resistant to change and that "traditional approaches to teaching natural selection through disconnected examples do little to involve students in real world discussions about the implication of evolution" (Cook, 2009, p. 95). In the PBL approach, teachers act as facilitators to student learning. Students can use technology to explore and guide their own learning, organize their work and manage their own time. This is consistent with the social-constructivist view of learning in which students are constructing knowledge in a social environment and problem solving is grounded in a social practice. Class members are encouraged to discuss ideas, debate points of view and critique each other's work, to increase their cognitive engagement with evolution on a social level. In addition, PBL aims to offer a scaffolding experience in learning evolution based on applications of the theory that is relevant to the student, including such subjects as cloning, genetic engineering and drug-resistant strains of pathogens.

Benson *et al*. (2009) proposes teaching the theory of evolution to college students using a broad interdisciplinary approach. The premise is that evolutionary theory has had an enormous impact on not just science, but on Western society as a whole. And understanding how Darwin's ideas have impacted disciplines outside of biology it will help students to more fully understand the biology behind the theory. A course with this theme was taught at Marian College, Indianapolis, Indiana in 2002, 2004 and 2006 which included an introduction to the science of evolution and then continued with teachers from non-science disciplines explaining how Darwin's ideas impacted their discipline. Such disciplines included language, art, literature, political science, modern culture, theology and sociology.

Parallels were drawn between these disciplines and evolution in an attempt to strengthen evolutionary thought in every part of a student's education. For example, the free market was discussed by the political science teacher in regards to natural selection and survival of the fittest. Those who became wealthy by their own initiative and skills were deemed more fit to live then those who were poor and a dead weight to society.

In another instance the English teacher presented the evolution of language in light of the origin of certain vocabulary words. After being exposed to these interdisciplinary impacts of evolution the students were asked how they related to biological evolution. The subject of the creation/evolution controversy was brought up with the teachers of modern culture, theology and sociology. The professor of theology taught on this subject that evolution precluded interpreting the Genesis account of creation in a literal sense. He added that there were fallacies in the literalist approach to reading the Genesis account of creation. The sociology professor led the class in a discussion of the effect of the creation/evolution debate on society and posed such questions as, "Why after 150 years are we still having this debate?" (Benson, 2009, p. 56). Students were told to consider how the creation/evolution debate will affect the science literacy of students.

The constructivist framework is adopted again to teach evolution in an article by Baumgartner & Duncan (2009). They are concerned that national polls show that over 45% of Americans do not accept the theory of evolution by natural selection and point out that alternate ideas and misconceptions about natural selection cause students to be highly resistant to change thier views toward evolution. Educational emphasis on microevolutionary processes is said to have left both teachers and students with a poor understanding of macroevolution and speciation.

They also state that a missing component of science education is evident in the lack of understanding on what constitutes a scientific theory. Students should be exposed to studies on the nature of science so that they are better able to distinguish the difference between a scientific theory and the usage of the word theory to mean a guess or unsupported explanation. It is pointed out that a common misconception about evolution is that it is "just a theory." And that the challenge to teaching concepts such as natural selection through the process of inquiry is that student beliefs will interfere with the inquiry, whereas the goal of instruction may be a conceptual change of the beliefs hindering the process. The author's description of the constructivist learning includes assimilation of new ideas into existing world-views, and the shifting of those worldviews to accommodate the new ideas. Building new concepts into ideas and beliefs of the students through the constructivist lessons, assimilation, and accommodation can occur as they build knowledge through experiences both inside and outside the classroom. Along with the discussion of the benefits of constructivist philosophy, a list of constructivist activities are given to teach natural selection. Surveys were given to high school students before and after these constructivist activities to decipher their knowledge and attitudes about natural selection and determine the effectiveness of the lessons. Overall, there was a significant difference in attitude change after instruction in each category surveyed.

The implementation of an instructional strategy, "structured academic controversy" (SAC), proposed by Khourey-Bowers (2009), is another means of teaching evolutionary theory while maintaining a constructivist approach. This strategy is based on Barbour's (2000) typologies of contemporary perspectives which describe relationships between science and religion and provide relative degrees of exclusionary or inclusionary thinking of the concepts that could be explored through either or both disciplines. The typologies (Conflict, Independence, Dialogue, and Integration) allow for an organizational scheme in which to base SAC. One main purpose to SAC is to avoid areas of conflict in teaching controversial topics such as evolution.

> Structured academic controversies are designed to engage students in controversy and then guide them to seek agreement. Students research and present a position, refute opposing positions, reverse perspectives, and create a synthesis that all group members can agree to (Khourey-Bowers, 2009, p. 44).

The authors state that much of the resistance in teaching evolutionary theory is attributed to lack of understanding of the nature of science and other resistance may be the result of deeply held personal beliefs or community expectations. Furthermore, it is stated that science teachers should avoid debating against creationism because the debate implies that one theory holds dominance over the other. And debates force a decision between two ideas rather then seek agreement. In conclusion, the SAC process guides students through many different religious and philosophical

positions and their relationships to scientific theories. And through this process, “religion is no longer perceived as a single block of beliefs or values, but rather a continuum from literal to liberal insights” (Khourey-Bowers, 2009, p.46).

Another constructivist approach to teaching evolutionary theory in high school was The Founder Effect by Leonard and Edmondson (2003). This is a standards based activity that utilizes the Hardy-Weinberg Equilibrium Equation; an equation developed by English mathematician Godfrey Hardy and German physician Wilhelm Weinberg early last century. The Founder Effect is a type of genetic drift; a phenomena that changes the genetic composition of a population. The authors of this article are proposing that more ways are needed to teach the students in an engaging, constructivist manner due to the difficulty in comprehending the relatively abstract concept of evolution. In this regard, evolutionary mechanisms will not be incomprehensible to the general public, and there will be less public resistance to the teaching of evolution in the United States. The authors further state that the use of mathematics is infrequent in the high school biology classroom, so this approach would be valuable to enrich the biology curriculum. National Science Education Standards that correspond with this activity include Biological Evolution; all species evolve over time, and natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms.

Settelmaier (2010) proposed an integral perspective on teaching evolution that allowed for a presentation of multiple perspectives to students. The title of the article, *The Conflict on Genesis: Building an Integral Bridge Between Creation and Evolution,* does not reflect the negativity of the author’s views toward the creation perspective. Such phrases as “epistemological narrow-mindedness” and “already backward populace of the so-called American Bible Belt” display the clear anti-creation attitude of the author. David Long’s article against the new Creation Museum in Kentucky founded by Answers in Genesis is discussed, in which the Museum is said to have a dumbing down effect. The “censored” take on evolution due to public pressure to ban teaching on evolution is equated to witch hunts, book burnings, concentration camps and intolerance. The author goes on to discuss museums as educational power hubs and their role in science education, American’s future in the hands of science educators and what the claim is the lack of separation of church and state in the United States. Furthermore, there is a discussion on hermeneutics and some of the history of the Christian church along with the origin of the Bible.

It is then proposed that the main reason for the creationist and evolutionist clash lies with the misappropriation of each other’s epistemologies: the creationists with their literal approach to the Book of Genesis and the evolutionists are transgressing into the religious domain with their zeal and moral righteousness in condemning creationism or anything religious as a misleading hoax. The author then goes on to state that “integral theory holds that every paradigm has something important to contribute to the endeavor of human knowledge construction and consciousness development” (Settelmaier, 2009, p. 248). By adopting an integral perspective, multiple perspectives are allowed, each having their own legitimate place and recognition of interconnectedness. An alternative of the two Grand Narratives, creation and evolution, is proposed to be replaced by “an integral perspective on the legitimacy of the co-existence of multiple perspectives through employing integral logic” (Settelmaier, 2009, p. 248).

Latham & Scully (2008) believe that the agents of evolutionary change are the best argument for evolution remaining the central theme of biology and in convincing the general public of its importance. They propose the use of the computer model "Critters!" to study evolution. Not only are today's students accustomed to computer games that are conceptually sophisticated such as "Critters!", the use of a computer model reduces time and budgetary constraints in the classroom. This computer model can simulate the genetic system and the gene/environment interactions of real populations. Students are also able to see the effects of the interaction between processes such as mutation and selection. After running the model or seeing screen shots of the model's organisms, students can test traits that might be influenced by an evolutionary mechanism. This program provides great flexibility for students in what to study and how to study it which is a central theme of inquiry-based learning.

Alles (2001) reports on his efforts to teach the nature of science and use evolution as a framework for teaching biology. Alles teaches a nonmajors general biology course at Western University in Washington. His course is experimental and doesn't follow the traditional scope and sequence for a typical general biology class. The difference is that evolution and the history of life are used as the curriculum framework and an extensive unit on the history and philosophy of science has been added. Alles adds that his experience teaching the course serves as an unintended test case for the National Academy of Science's (NAS) recommendations on teaching evolution and the nature of science.

The purpose of NAS recommending that evolution be the conceptual framework for teaching biology stems from the understanding that curriculum development in science education should be based on the synthesis inherent in the scientific paradigms. Scientific paradigms are scientific theories that unite an entire field of scientific study. The author believes that the history of life on Earth contains the explanation for the origin of every aspect of the living world, and by using a narrative presentation of the history of life evolution is automatically set as the framework for teaching biology. To accomplish credibility for science, Alles states that history and philosophy of science must be integrated into biology curriculum. In teaching the nature of science, students are taught what acceptable evidence is by showing the contrast between what is acceptable evidence in science as opposed to what is acceptable evidence in theistic religions. In this light the stage is set for a nonconfrontational presentation of evolutionary theory. This method of defining science focuses the attention on physical evidence alone to understand the natural world. However, the author adds that it is not necessary to directly observe every event in the natural world to understand it scientifically. Historical sciences depend on logical inference from physical evidence in the present to scientific conclusion about the past.

An article by Flammer (2006) discusses a technique in teaching evolution that attempts to avoid conflict. He states that often teachers are confronted by students about their disapproval of having to learn evolutionary concepts. But, he believes that evolution is a well-documented process and that it is a disservice to students to teach biology without an accurate and comprehensive treatment of it. He speaks against texts that launch suddenly into evolution without any clear segue or connections to biology defending the topic with numerous examples of "evidence." He calls this a "fortress mentality" that feeds the defensiveness and practiced arguments against evidence from students with anti-evolution views. The author proposes a program that he believes effectively addresses this issue, using a series of interactive lessons

while minimizing conflict. The students in turn will then recognize misconceptions and understand why evolution is considered one of the strongest scientific theories. He found that once the format of his course was developed objections to the strong evolutionary content declined. The effectiveness of this approach is believed to be closely tied to the sequence of topics: the nature of science, an overview of life, an introduction to evolution to provide testable answers and using evolution as a unifying theme throughout the course. The second critical element, the author adds, is the selection of lessons used. He highly recommends using the "5 E" framework promoted by the Biological Sciences Curriculum Study Program (Engage, Explore, Explain, Elaborate, and Evaluate) to present the material. As the teacher continues through the sequence of topics which touch on ideas that can be tied to evolution, there is no mention of evolution. The students are then asked to come to conclusions based on the experience of standard biological topics that raise a number of puzzling questions.

At this point, if students have not initiated the discussion on the topic of evolution, the teacher can interject evolutionary explanations to prompt students to suggest evolutionary processes. When encountering challenges from students, the author gives tips on how to respond to specific objections from the students. He warns teachers to not fall into the trap of rebutting every challenging comment but to direct students to resources that defend evolution such as *TalkOrigins* and *NCSE* sites, [both which are biased evolutionary teaching and strongly against creation and intelligent design (ID)]. If students bring up the subject of creation or ID, he advises teachers to tell them that religious themes are not appropriate for discussion in the science classroom. Furthermore, teachers are to avoid any comments that might trigger defensiveness with students. And finally, the author tells teachers to let the lessons speak for themselves and "at least *your* students – if their minds haven't been closed by defensiveness – will have a more accurate understanding of evolution, and they might even be convinced of its validity" (Flammer, 2006, p.5).

Another article proposing the "5 E" format, Burton and Dobson (2009) use plastic utensils as model organisms in an exercise to address evolutionary misconceptions. Genetic variability of the organism, *Utensilus plastica*, is used to explore evolutionary concepts. In this lesson, students "reconcile their explanations of concepts with actual observation testing their developing understanding and preconceptions of evolution." The author states that students can gain a deeper understanding of natural selection and evolution using these plastic utensils. The lesson plan is in the 5E format in accordance with the constructivist learning model. Being that the whole scenario with using plastic utensils is a humorous spoof; students are engaged by the subject as they investigate the different species of spoons, sporks and forks. The author believes that the concrete approach to this lesson plan will reduce the likelihood of students forming new evolutionary misconceptions and challenges them to struggle with the abstract thinking that accompanies the concepts of natural selection and evolution.

Research Question 3: What resources are used to teach students about the origins of the universe?

Alles and Stevenson (2003) wrote an article to show the importance of teaching human evolution to all students and provide up-to-date resources for classroom teachers to use in teaching the subject. They state that secondary biology textbooks are limited in staying current in

paleoanthropology due to their mass production and the rapidly changing scientific field. The authors attempt to compensate for this limitation in this article.

After the authors state that "modern science has reached the point where the broad outline of our origin is known," teaching human evolution is discussed as being central to each person's individual worldviews. It defines who and what we are. The beliefs we hold about ourselves drive our attitudes and actions and in turn determine what kind of people we are and what kind of society we have.

> The authors state:
> In the past we answered the questions about our origins with the myths and creation stories unique to the culture of our birth. But today we live in a world where scientific answers to these questions are available….it is the knowledge of who and what we are that we can hold in common in our increasingly pluralistic society (Alles & Stevenson, 2003, p. 333).

The authors then give a review of current research on human evolution between the late Miocene eight million years ago and 100,000 years ago, marking the evolutionary transition from the last common ancestor with modern chimpanzees to the first fully modern humans. An overview of hominin evolution is given following descriptions of the earliest hominins, Australopiths and related genera, robust hominins, early homo and later homo, and finally modern humans.

In summary, the authors explain that new fossil discoveries or early ancestors are occurring at an increasing rate causing paleoanthropologists to shuffle names to accommodate these new discoveries. It is stressed that the general outline of human evolution remains and that these changes are signs of healthy activity. It is stated:

> Shifts in opinion are not a reflection of some inherent weakness,…rather it shows the subject in a healthy state of chaos around a slowly growing fixed framework. Confusion is a sign that we are doing something right; it is the fertile commotion of a construction site (Alles & Stevenson, 2003, p. 338).

In conclusion, the authors list a number of recommended books and websites.

Alles (2001) notes some resources in teaching evolution that he has used in his college biology course. This course, explained above, uses evolution as a framework for teaching biology. He recommends a booklet called *Teaching about Evolution and the Nature of Science* which was published in 1998 by the National Academy of Sciences (NAS). Rather then treated evolution as a separate topic, the booklet challenges teachers to use evolution as the organizing theme in teaching biology. The motives or recommendations of NAS to teach by this framework are explained above. The NAS also emphasizes the importance of teaching the nature of science due to the large number of American adults that accept the literal interpretation of the Bible, including the story of creation and the age of the Earth, and because an even larger number of Americans think creationism should be taught along with evolution in public schools.

The author also recommends two recent books on the nature of biology: Ernst Mayr's *This is Biology* (1997) and Michael Ruse's *Mystery of Mysteries: Is Evolution a Social Construct?*

(1999). Mayr's book is an overview of the history and philosophy of biology written for the general public. Ruse's book provides a summary of the recent history of the philosophy of science by contrasting the philosophies of Sir Karl Popper and Thomas Khun. The balance of Ruse's book is devoted to biographic portraits of some scientists in the history of evolutionary biology, such as Erasmus Darwin (Charles Darwin's grandfather), Theodosius Dobzhansky who coined the phrase "nothing in biology makes sense except in light of evolution (Dobzhansky, 1973)", Richard Dawkins, and Stephen Jay Gould.

The course includes a conceptual framework of biology in which cosmological evolution is used to demonstrate a broader view of evolutionary change. This provides opportunity not only to explain the causal relationship behind evolution in biological systems, but in the universe as a whole. The author recommends some resources for an introduction to this topic: Jacob Bronowski's essay *New Concepts in the Evolution of Complexity* (1997) and two books on cosmological evolution by Timothy Ferris titled *Coming of Age in the Milky Way* (1988) and *The Whole Shebang* (1997), which contain ideas on both the evolution of the universe and life on Earth.

Since no textbooks are currently on the market that follow the scope and sequence the author uses in his course in biology, he has made his lecture notes readily accessible. He does recommend some books that could be used as texts on the history of life, such as *The Book of Life* edited by Stephen Jay Gould (1993) or *A Walk Through Time: From Stardust to Us* by Liebes, Sahtouris and Swimme (1998).

Flammer's article, *The Evolution Solution: Teaching Evolution without Conflict* (2006), as explained above, proposes a program that is supposed to effectively minimize conflict while students learn about evolution in the classroom. He states that most of the material for his program can be found in the *Evolution and Nature of Science Institutes* (ENSI) website that is a collection of student-centered interactive lessons and strategies gathered, designed, and classroom tested by over 800 biology teachers across the nation. Since the 5E framework is the basis of the author's program, he recommends a resource that demonstrates this protocol, *Teaching About Evolution and the Nature of Science* (NAS, 1998).

In discussing challenges that a teacher will face by introducing the topic of evolution, the author takes time to explain intelligent design (ID) and how it is filled with the usual fallacies and unscientific premises long associated with "scientific creationism" and other anti-evolution movements. It is stated that both ID and creation science are excellent examples of pseudoscience. Further reading on the unscientific nature of ID is recommended such as *TalkOrigins* and *NCSE* (National Center for Science Education) websites, both of which are strongly against the teaching of any other views on origins besides Darwinian evolution.

Labov (2005) of the National Academy of Sciences in Washington, DC, in response to challenges on science and science education regarding the topic of evolution wrote an article outlining a number of resources and activities teachers can use to confront these challenges. He states that messages from proponents of ID present a unified front, are clear and simple to remember (for example, "Teach the Controversy"), and resonate with a large number of people. He exhorts the evolutionary scientific community to do the same.

The National Academy of Sciences (NAS) has made its institutional statements, publications, and other resources on evolution and evolution education available to the public for many years. However, recently an evolution webpage (*Evolution Resources,* http://www.nas.edu/evolution/) was constructed that compiles all this information with links to the Academy's resources on evolution education and to other resources.

The NAS has published three reports to help teachers and the public better understand evolutionary principles and the controversies surrounding evolution education. They include *Teaching about Evolution and the Nature of Science* (NAS, 1998); *Science and Creationism: A View form the National Academy of Sciences, 2nd ed.* (NAS, 1999), and *Evolution in Hawaii: A Supplement to Teaching about Evolution and the Nature of Science* (2004).

Standards for teaching science in grades K-12 are based in part on curricular and content recommendations in the *National Research Council's National Science Education Standards* (1996). The Standards articulate clear guidelines about what students should know and be able to demonstrate an understanding of evolution.

The current edition of *Science and Creationism* is being revised due to the new ID movement. The updated publication will provide more information on the ID concept and why the scientific community does not consider it to be a scientific theory.

A book called *Genesis: The Scientific Quest for Life's Origins,* authored by Robert Hazen, a geophysicist at the Carnegie Institute of Washington is recommended. It provides information on current theories of life's origins and the evidence supporting these ideas. Hazen concludes by stressing the importance of equipping students with the knowledge and understanding of science so as that our future leaders will confront these challenges in evolution education. He states that opportunists pit science against religious belief, as if they are on opposite ends of the spectrum. And, he argues, if we can help students understand that, by its very nature, science is incapable of addressing theological questions, we may begin to defuse these bitter debates.

In the article by Herron, Kingsolver, Meir, and Perry (2007), *College Students' Misconceptions about Evolutionary Trees,* discussed above regarding measurements, the concern exists that little attention is focused on lessons teaching macroevolution. A new simulation software package called EvoBeaker is introduced that can be used to teach college-level evolutionary biology through simulated experiments. Micro- and macro-evolutionary laboratories are built into the program. The software design begins by seeking to identify misconceptions with college students concerning evolutionary trees, the diagrams used to display branching evolutionary relationships between populations or species, and the ideas embedded in these diagrams.

The article's main focus is measuring college students' understanding of the concepts of phylogenetic trees. The authors state that the "misconceptions found are fundamental barriers to understanding how evolution operates" and that "phylogenetic reasoning is central to much contemporary research on evolution (Herron *et al*., 2007, p. 76)." The students that are "lacking a solid understanding" of the concepts on the authors tests are said to be likely to have a difficult time relating the disparate areas of biology through evolutionary thinking. Because of this fact, it

is stressed that tools which go beyond standard techniques for teaching tree-thinking are sorely needed.

Understanding Evolution (*UE*, http://evolution.berkeley.edu/) is a website with two major components that deliver accessible information to K-12 teachers, their students, and the general public. Scotchmoor and Thanukos (2007) introduce this website as a valuable teaching resource for teachers who teach evolution in an article titled *Building an Understanding of Evolution: an Online Resource for Teaching and Learning*. The site explores topics in evolutionary biology, with the purpose of leading to better understandings of evolution and how it impacts peoples' lives. The website provides for teachers "clarification of common misconceptions, a conceptual framework, a searchable database of more then 100 vetted lessons, and strategies to overcome roadblocks to teaching evolution" (Scotchmoor & Thanukos, 2007, p. 226). Additionally, the site has features that target students and the public. This includes "interactive content modules for different audiences, in-depth student investigations, exemplars of evolution, a comic strip, research profiles, FAQ's on the 'controversy' surrounding evolution, and a monthly news brief titled *Evo in the News*" (Scotchmoor & Thanukos, 2007, p. 226).

The rationale behind building the website is that Americans have a poor understanding and acceptance of how evolution affects many aspects of their lives and is the central organizing theme that biologists use to understand the world. Also, there is a sizeable segment in America that rejects evolution as a valid explanation for the diversity of life. Furthermore, many students demonstrate significant misconceptions and misunderstandings of evolutionary processes.

Research Question 4: What evidence exists regarding stability/change in students' views of the origins of the universe?

"Student beliefs are likely to reflect those of the American population as a whole, and many people still find the teaching of evolution in the schools to be a controversial issue" (Bentley, 2000, p. 64). With this in mind, the following statistics are presented: The Pew Forum on Religion and Public Life and the Pew Forum (2006) conducted a study on Americans' views on mixing of religion with politics. They polled 2,003 adults on the influence of religion in such areas as public life, politics and science. The survey found that there is continuing tension in the public's views of science and religion, especially in opinions about evolution and the origins of life and the issue is highly divisive. It was found that 65% of white evangelical Protestants reject the notion that humans and other living things have evolved over time, and they espouse the view that life has existed in its present form since the beginning of time. Just 28% of evangelicals believe in evolution and 6% think evolution occurred by natural selection. Among seculars and most other religious groups, 59% Catholics, 62% mainline Protestants and 83% seculars believe in evolution. There is division between religious groups as to whether evolution occurred by natural selection or was guided by a supreme being.

In a Gallup poll study on Evolution, Creationism and Intelligent Design (2010), various polls over recent years are reported to show stability and/or change of public views on these subjects. Participants in the study were asked which of the following statements come closest to their views on the origin and development of human beings: human beings have developed over millions of years from less advanced life forms, but God guided this process, human beings have

developed over millions of years form less advanced forms of life, but God had no part in this process, (or) God created human beings pretty much in their present form at one time within the last 10,000 years or so? The first poll, taken in 1982 found that 44% thought God created man in present his form, 38% thought man developed with God's guidance, and 9% thought that Man developed, but God had no part in the process. In 1993, the same polling showed percentage of 47%, 35%, and 11% respectively. Seven more polls were conducted between the years of 1998 and 2008 in which, for the most part, the percentages fluctuated slightly, yet changed significantly only in the last few years. In 2008, the percentages were found to be 44%, 36%, and 14%, respectively, noting a jump in those who believe that man developed, but God had no part in the process. Throughout the years of polling the percentages of participants who had no opinion were small, in the range of 4-9% of those who were surveyed. A 2007 Gallup poll was conducted that asked participants about their views on the two different explanations for the origin and development of life on Earth. The following statement was asked in regards to whether it was true or false: evolution, that is, the idea that human beings developed over millions of years from less advanced forms of life. The percentage of participant who said this was definitely true was 18%, 35% said it was probably true, 16% said it was probably false and 28% said it was definitely false. For the statement: creationism, that is, the idea that God created human beings pretty much in their present from at one time within the last 10,000 years, 39% said definitely true, 27% said probably true, 16% said probably false, and 15% said definitely false.

In 2005 a similar Gallup poll was conducted. Participants were asked to state their beliefs on creationism, evolution and intelligent design. For creationism 58% of participants said definitely/probably true, 26% said definitely/probably false and 16% had no opinion or were not familiar with the concept. For evolution the percentages were 55%, 34%, and 11% respectively and for intelligent design the percentages were 31%, 32%, and 37% respectively.

Amirshokoohi, Donnelly and Kazempour (2008) report that in the US, roughly half to three quarters of all students accept evolution, however there are very few studies that have examined high school students' acceptance of evolutionary theory. In two surveys of high school biology students by Woods & Scharmann (2001) and Lawson & Worsnop (1992), student acceptance of evolutionary theory ranged from 35% to 69% acceptance respectively. Student acceptance of evolution can assume a variety of meanings and rejection does not imply that the student rejects evolutionary theory completely. Acceptance is related to many ideas pertaining to acceptance of evidence for evolution, the status of evolution within science, the explanatory power of evolution, and the relationship between evolution and religion, among others. In a study conducted by Sinclair *et al*. (1997), a survey of college students found that less than 20% of the students viewed evolution as not conflicting with their religious views. Two other college surveys found that about three quarters of the students maintained that a person can accept evolution and believe in God.

One of the purposes of the authors' study is centered around a theoretical framework called border crossing and the extent to which border crossing differs for evolution acceptors and rejecters. Border crossing is the crossing of a cultural border that students cross from the subcultures of peers and family, to the subcultures of school science and science. The measurements used in their student surveys are discussed above. The MATE survey revealed that

out of 29 students, 11 were classified as acceptors of evolution while 18 were classified as rejecters of evolution. Acceptance and rejection were defined by means of the degree of which students accepted or rejected evolution. Few students reject or accept evolution in its entirety, but may agree or disagree with different aspects of evolution.

> Moore and Cotner (2009) report that:
> Despite decades of science education reform, numerous legal decisions declaring the teaching of creationism in public-school science classes to be unconstitutional, overwhelming evidence supporting evolution, and the many denunciations of creationism as nonscientific by professional scientific societies, creationism remains popular throughout the United States (Moore & Cotner, 2009, p. 429).

They also state that creationism continues to be popular among biology teachers, and as much as 20-35% of high school biology teachers include creationism in their courses. They explain that some states even encourage teachers to promote creationism such as section 158.177 of the Kentucky Revised Statutes which allows teachers to teach the theory of creation as presented in the Bible and to reward students on exams for answers based on Biblical creationism. In the survey given to college students using the MATE instrument, it was found that 45.3 percent advocated creationism with such statements as: "I believe in creationism and intelligent design," or "I do not believe evolution happened." The percentage of students that expressed uncertainty whether to believe in creation or evolution was 34%.

Research Question 5: What factors are identified that contribute to stability? What factors are identified that contribute to direction and magnitude of change?

Cavallo and McCall (2008) stress the importance of a student's beliefs about science in regards to their ability to learn about evolution. They state that it is likely most secondary biology students have been exposed to some opinions about evolution from parents, religious leaders, or media before entering the classroom. And this exposure has most likely helped students form ideas and beliefs about evolution prior to formal instruction. The authors state that the problem is further compounded by students' misunderstandings of the scientific aspects of evolutionary theory. The personal views of the world and potential misunderstandings need to be clarified and considered prior to instruction. The measurement of their study explored patterns and interrelationships among students' belief and evolution and the nature of science and their conceptual understandings of evolution.

In the study conducted by Cavallo and McCall (2008), they explored the patterns and interrelationships among high school students' beliefs about the theory of evolution and the nature of science, and their conceptual understanding of evolution. They examined shifts in students' beliefs about evolution before and after a four-week instructional unit on evolution. The post-instructional questionnaires and tests were used to examine shifts in the students' beliefs on evolution, finding that student beliefs did not change during the course of the instruction. The authors state, "This finding corroborates the literature that reports beliefs as deeply entrenched in one's persona and unlikely to change in a short period of time" (Cavallo & McCall, 2008, p. 527).

The study by Moore (2007), attempts to answer the question why so many students question, reject, and know so little about evolution. From 2003 to 2006, he surveyed 1,441 undergraduate student enrolled in a large introductory biology course at the Twin Cities campus of the University of Minnesota. He questioned them on their education experiences in high school biology in regards to being taught creationism or evolution. In public schools, most students were taught evolution but not creationism. In private high schools, most students were taught both creationism and evolution, but a substantial percentage were taught evolution and not creationism. It was also found that high school biology teachers in public and private schools who teach creationism usually present only a particular version of the Judeo-Christian story of creation; other stories are usually ignored.

The author concludes from his survey that 3% of biology teachers at public schools teach creationism and not evolution, and more than 20% of biology teachers at public schools teach both evolution and creationism. He states that the data presented in his study show that a large number of students in the nation's high schools are getting educations shaped by creationist influence, in spite of overwhelming opposition of the nation's scientific, educational, and media establishments. He blames high school biology teachers who teach creationism.

Robbins and Roy (2007) conducted a study on identifying and correcting non-science student preconceptions through an inquiry-based, critical approach to evolution. Their motivation to complete the study was due to schools today facing political pressure to adopt a critical approach to teaching evolution. They chose to challenge both preconceptions and newly-formed conceptions of students toward evolution. A four-lesson unit was conducted with 141 college students along with an initial pre-essay and pre-quizzes before lessons to identify and respond to common misconceptions. During the lessons, instead of teaching evolution as a separate unit, it was used as a lens though which other topics were examined such as natural history and biochemistry. After the lessons, the students were assessed for their understanding by both an objective test and through student writing.

Pre-essay results showed that the majority of students (59%) said that they accepted evolution. The percentage of students that believed that evolution was God's mechanism for producing the diversity of life, and is compatible with religion, was 9%. The percentage of the students that offered conditional support in that they believe evolution happened with animals but man was created by God was 8%. And, 8% of students advocated Biblical creationism as the only acceptable explanation for the diversity of life.

The lessons were then prepared with student answers in mind with the purpose of tackling preconceptions of evolution the students stated when quizzed. Students were also given time during the lessons to discuss amongst themselves the misconceptions. Also, in order to overcome cognitive dissonance in challenging preconceptions, handouts were given to the students with several quotes from scientists, religious authorities and the students themselves from the pre-quiz. One such student quote read, "Genesis is not science. It is a myth, and seeks not so much to delineate the facts of the external world as to posit a statement as to its inherent worth ('and it was good')" (Robbins & Roy, 2007, p. 463). The lessons included exercises examining the different lines of evolutionary evidence.

By the end of the course, the majority of students (92%) stated in a survey that evolution was the best explanation we have for the evidence that we see. The authors state, “While we cannot test the long-term retention in our students, the shift in perception we observed suggests a fundamental and lasting change” (Robbins & Roy, 2007, p.465). The results are attributed to the inquiry based approach toward evolution presenting the evidence in light of students’ preconceptions.

Deckard and Sobko (1998) developed an instrument for measuring a Christian Creationist worldview. The purpose in doing this study was to measure the basic elements of a creationist worldview in order to present a “Young Earth Christian Creationist Worldview” in a manner which is usable and understandable for secondary level science teachers and their students. The authors explain that there are two basic alternatives in exploring the science and their relationship to worldview formation, the creationist worldview and the evolutionist worldview. It is pointed out that a fundamental problem in most secondary school science classrooms is that the teaching is aimed at the acquisition of knowledge at the memorization level, and very little is done in the realm of interpreting the data and development of thinking skills. Science is not a set of facts to be memorized, but rather a dynamic volume of concepts and principles to be interpreted and integrated into one’s worldview. Students should be exposed to the fact that certain scientific knowledge is tentative, certain scientific knowledge is unchanging, and certain scientific knowledge is yet to be discovered. This view and understanding of scientific knowledge helps one to understand why the measurement of a student’s worldview is imperative. The authors state:

> A student’s belief (worldview) affect is or her understanding about scientific knowledge and thus about how science works. At a more fundamental level, the student’s belief system affects his or her interest in science. Because these factors and other factors are present within the student before entering the science classroom, it is important to the teacher to be able to discern the student’s worldview (creationism/evolutionism). Thus the need for being able to measure a student’s worldview as it relates to creation/evolution is established (Deckard & Sobko, 1998, p. 3).

Forces and factors pointed out that affect the development of personal worldview particularly in secondary science are textbooks, teachers, and curricular materials.

CONCLUSIONS

This literature review revealed numerous ways in which students’ views on origins are measured along with what techniques are used to teach origins. Also, there exists a number of resources to teach origins, but they are all one-sided toward teaching evolution. Studies on the stability and change of students’ views origins and the factors contributing to them are few. Numerous articles touch on the subject of conducting a study; mainly researchers will project opinions on the matter rather than present research findings.

This study is useful to both educators, parents of students attending public school and students themselves. Creation science educators can use the same techniques suggested here to teach science with a Biblical worldview. It is also important for Christian educators to prepare their

students and themselves for what may be encountered in the secular world that is contrary to science and their faith. It is beneficial for Christians to study what the world teaches to better understand their own faith and worldview.

Parents of students attending public school and the students themselves can use this information to better prepare for what they may encounter in the science classroom. It is imperative that we prepare our children in encountering the outside world and its secular influences and teach them how to respond according to scripture. Furthermore, as believers we are called to have an answer to the hope that is within us and not passively agree with false beliefs that compromise our faith. "But in your hearts set apart Christ as Lord. Always be prepared to give an answer to everyone who asks you to give the reason for the hope that you have. But do this with gentleness and respect" (1 Peter 3:15, New International Version).

It is suggested, due to the strongly held beliefs against creation within the evolutionary education community evidenced in this paper, that parents do not send their children to school to fight this battle alone. Parents may make objections to schools when they disagree with how their child is being taught in the science classroom. Many of the studies presented in this paper were influenced by conflicts in the classroom that occurred on the subject of evolution. Staying silent may cause educators to loosen their guard in this controversy and they may be more open to influencing students toward their worldview if no opposition exists.

Furthermore, this study confirms that the controversy between evolution and creation is alive and well in the schools. Polls show that the percentages of those who believe in creation are not dropping dramatically. This can be a source of encouragement for believers to keep with their faith alongside other believers across the nation who are fighting the battle for a Biblical worldview on origins.

Suggestions for Further Research

1. How much stability and change in students' views of the origin of the universe is occurring?
2. What factors contribute to stability and change in views on the origin of the universe?
3. What is the parents' role in a student's views on the origin of the universe?
4. What resources are available for students to counteract the teaching of evolution experienced in the classroom?

REFERENCES

Alles, D. (2001). Using evolution as the framework for teaching biology. *The American Biology Teacher*, *63*(1), 20-23.

Alles, D. and Stevenson, J. (2003). Teaching human evolution. *The American Biology Teacher*, *65*(5), 333-339.

Amirshokoohi, A., Donnelly, L., and Kazempour, M. (2009). High school students' perceptions of evolution instruction: Acceptance and evolution learning experiences. *Research in Science Education, 39*, 643-660.

Baumgartner, E. and Duncan, K.D. (2009). Evolution of students' ideas about natural selection through a constructivist framework. *The American Biology Teacher, 71*(4), 218-227.

Benson, D., Atlas, P., Haberski, J. H., Higgs, J., Kiley, P., Maxwell, M., Mirola, W., and Norton, J. (2009). Teaching the broad interdiscipinary empact of evolution. *Bioscene, 35*(1), 53-57.

Bentley, M. (2000). Improvisational drama and the nature of science. *Journal of Science Teacher Education, 11*(1), 63-75.

Blackwell, W., Dukes, G., and Powell, M. (2003). The problem of student acceptance of evolution. *Journal of Biological Education, 37*(2), 58-67.

Branch, G. and Scott, E.C. (2008). Overcoming obstacles to evolution education: in the beginning. *Evolution Education Outreach, 1*, 53-55.

Branch G. and Scott, E. (2008). Overcoming obstacles to evolution education: The OOPSIE compromise – a big mistake. *Evolution Education Outreach, 1*, 147-149.

Braterman, P., and Holbrook, B., (2009). Putting Darwin in his place: The need to watch our language. *The American Biology Teacher, 71*(2), 84-88.

Brem, S., Evans, M. and Sinatra, G. (2008). Changing minds? Implications of conceptual change for teaching and learning about biological evolution. *Evolution Education Outreach, 1*, 189-195.

Burton, S. and Dobson, C. (2009). Spork & beans: Addressing evolutionary misconceptions. *The American Biology Teacher, 71*(2), 89-91.

Cavallo, A. and McCall, D. (2008). Seeing may not mean believing: examining students' understandings & beliefs in evolution. *The American Biology Teacher, 70*(9), 522-530.

Cook, K. (2009). A suggested project-based evolution unit for high school: teaching content through application. *The American Biology Teacher, 71*(2), 95-98.

Cotner, S. and Moore, R. (2009). The creationist down the hall: Does it matter when teachers teach creationism? *BioScience, 59*(5), 429-435.

Deckard, S. and Sobko, G.M. (1998). *Toward the development of an instrument for measuring a Christian creationist worldview*. Retrieved June 9, 2010 from http://www.icr.org/article/christian-creationist-worldview/.

Dobzhansky, T. (1973). Nothing in biology makes sense except in light of evolution. *The American Biology Teacher, 35*, 125-129.

Edmondson, E. and Leonard, W. (2003). Teaching evolution through the founder effect: A standards-based activity. *The American Biology Teacher, 65*(7), 538-541.

Evolution, Creationism, Intelligent Design (2010). Retrieved May 21, 2010 from http://www.gallup.com/poll/21814/evolution-creationism-intelligent-design.aspxGallup poll reference.

Evolution Resources (2013). Retrieved February 20, 2013 from *http://*www.nas.edu/evolution/

Flammer, L. (2006). The evolution solution: teaching evolution without conflict. *The American Biology Teacher*, Online Publication, *68*(3), 1-6.

Hatch, J., Hsu, L., Jenson, M. and Moore, R. (2007). A scoring rubric for students' responses to simple evolution questions: darwinian components. *The American Biology Teacher*, *69*(7), 394-399.

Herron, J., Kingsolver, J., Meir, E., and Perry, J. (2007). College students' misconceptions about evolutionary trees. *The American Biology Teacher*, *69*(7), 71-76.

Ingram, E.L., and Nelson, C. E. (2006). Relationship between achievement and students' acceptance of evolution or creation in an upper-level evolution course. *Journal of Research in Science Teaching*, *43*(1), 7-24.

Khourey-Bowers, C. (2006). Structured academic controversy: A peaceful approach to controversial issues. *The American Biology Teacher, 68*(5), 43-47.

Labov, J. (2005). From the National Academies: Ongoing challenges to evolution education: resources and activities of the National Academies. *Cell Biology Education, 4*, 269-272.

Latham, L. and Scully, E. (2008). Critters! A realistic simulation for teaching evolutionary biology. *The American Biology Teacher, 70*(1), 30-33.

Lawson, A. E., and Worsnop, W. A. (1992). Learning about evolution and rejecting a belief in special creation: effects of reflective reasoning skill, prior knowledge, prior belief and religious commitment. *Journal of Research in Science Teaching*. *29*(2), 143-166.

Many Americans Uneasy with Mix of Religion and Politics. (2006). Retrieved May 20, 2010 from http://pewforum.org/Politics-and-Elections/Many-Americans-Uneasy-with-Mix-of-Religion-and-Politics.aspx.

Matthews, D. (2001). Effect of a curriculum containing creation stories on attitudes about evolution. *The American Biology Teacher*, *63*(6), 404-409.

McKeachie, W.J., Lin, Y.-G., and Strayer, J. (2002). Creationists vs. evolutionary beliefs: Effects on learning biology. *American Biology Teacher*, *64*, 189-192.

Moore, B., Froehle, A.M., Kiernan, J., Greenwald, B. (2006). How biology students in Minnesota view evolution: The teaching of evolution and the evolution-creation controversy. *American Biology Teacher*, *68*(5), 35-42. Retrieved October 29, 2008, from Education Resources Information Center.

Moore, R. (2007). What are students taught about evolution? *McGill Journal of Education, 42*(2), 177-186.

Moore, R. (2007). The differing perceptions of teachers & students regarding teachers emphasis on evaluation in high school biology classrooms. *American Biology Teacher, 69*(5), 268-271. Retrieved October 29, 2008, from Education Resources Information Center.

Moore, R. (2008). Creationism in the classroom: What do teachers teach and how do they teach it? *American Biology Teacher, 70*(2), 79-84. Retrieved October 29, 2008, from Education Resources Information Center.

Morris, H. (1980). *The Tenets of Creationism*. Retrieved June 10, 2010 from http://www.icr.org/article/tenets-creationism/

National Academy of Sciences. (1998). *Teaching About Evolution and the Nature of Science.* National Academy Press, Washington, DC.

Pendarvis, M.P. and Sinclair, A. (1998). Evolution vs. conservative religious beliefs: Can biology instructors assist students with their dilemma? *Journal of College Science Teaching, 27*(3), 167-170.

Pennock, R.T. (2007). Learning evolution and the nature of science using evolutionary computing and artificial life. *McGill Journal of Education, 42*, 211-222.

Rankey, E.C. (2003). The use of critical thinking skills for teaching evolution in an introductory geology course. *Journal of Geoscience Education, 51*, 304-308.

Richards, R.A. (2008). Philosophical challenges in teaching evolution. *Evolution Education Outreach, 1*, 158-164.

Robbins, J. and Roy, P. (2007). Identifying & correcting non-science student preconceptions through an inquiry-based, critical approach to evolution. *The American Biology Teacher, 69*(8), 460-466.

Rutledge, M. and Sadler, K. (2007). Reliability of the Measure of Acceptance of the Theory of Evolution (MATE) Instrument with university students. *The American Biology Teacher, 69*(6), 332-335.

Scotchmoor, J. and Thanukos, A. (2007). Building an understanding of evolution: An online resource for teaching and learning. *McGill Journal of Education, 42*(2), Retrieved April 20, 2010, from http://mje.mcgill.ca/article/view/2221

Scott, E.C., (2007). What's wrong with the "teach the controversy" slogan? *McGill Journal of Education, 42*(2), 307-315. Retrieved October 29, 2008, from Education Resources Information Center.

Settelmaier, E. (2010). The conflict on genesis: Building an integral bridge between creation and evolution. *Cultural Studies of Science Education. 5*, 243-249.

Thompson, J.N. (2008). Use the word evolution. *Evolution Education Outreach, 1*, 42-43.

Varlese, E. (2007). To believe or not to believe? A college student explores knowledge and attitudes about evolution at her school. *Evolution Education Outreach, 1,* 96-99.